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IS 1248-9 (2003): Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories, Part 9: Test Methods [ETD 12: Measuring Equipment for Basic Electrical Quantities]

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भाग 9 परीक्षण पद्धतियाँ

(तीसरा पुनरीक्षण)

Indian Standard

DIRECT ACTING INDICATING ANALOGUE ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSORIES

PART 9 TEST METHODS

(Third Revision)

ICS 17.220.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

December 2003 **Price Group 9**

Measuring Equipment for Basic Electrical Quantities Sectional Committee, ET 12

FOREWORD

This Indian Standard (Part 9) (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Measuring Equipment for Basic Electrical Quantities Sectional Committee had been approved by the Electrotechnical Division Council.

This standard covers the test methods.

This standard was first published in 1958 and was revised in 1968 and in 1983. The third revision had been undertaken to align it with IEC publication.

This standard is one of a series of nine Indian Standards on direct acting indicating analogue electrical measuring instruments and their accessories. Other standards published in this series are as follows:

(Part 1) : 2003	Definitions and general requirements (*fourth revision*)
(Part 2) : 2003	Special requirements for ammeters and voltmeters (*third revision*)
(Part 3) : 2003	Special requirements for wattmeters and varmeters (*third revision*)
(Part 4) : 2003	Special requirements for frequency meters (*third revision*)
(Part 5) : 2003	Special requirements for phase meters, power factor meters and synchroscopes (*third revision*)
(Part 6) : 2003	Special requirements for ohmmeters (impedance meters) and conductance meters (*third revision*)
(Part 7) : 2003	Special requirements for multi-function instruments (*third revision*)
(Part 8) : 2003	Special requirements for accessories (*third revision*)

In preparation of this standard, assistance has been derived from IEC 60051-9 (1988) 'Direct acting indicating analogue electrical measuring instruments and their accessories : Part 9 Recommended test methods' fourth edition, issued by the International Electrotechnical Commission (IEC).

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DIRECT ACTING INDICATING ANALOGUE ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSORIES

PART 9 TEST METHODS

(Third Revision)

1 SCOPE

This standard (Part 9) specifies test methods for direct acting indicating analogue electrical measuring instruments and their accessories.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
IS 1248	Direct acting indicating analogue electrical measuring instruments and their accessories :
(Part 1) : 2003	General requirements (*fourth revision*)
(Part 3) : 2003	Special requirements for wattmeters and varmeters (*third revision*)
(Part 5) : 2003	Special requirements for phase meters, power factor meters and synchroscopes (*third revision*)
(Part 8) : 2003	Special requirements for accessories (*third revision*)

3 GENERAL TEST CONDITIONS

The test methods described in this part shall be applied under the following conditions unless otherwise specified.

3.1 Reference Conditions

Reference conditions shall be according to Table 1 of the relevant parts of IS 1248. Where a reference range is specified, tests shall be performed at both limits of the reference range.

3.2 Parallax

For an edgewise instrument, the line of vision should be perpendicular to the instrument dial at the index tip.

For an instrument having a mirror scale, the line of vision should be such that the index tip is coincident with its reflection in the mirror.

NOTE — Care should be taken to avoid the effect of parallax error when taking instrument readings.

3.3 Tapping

Immediately prior to taking a reading, either the instrument or its support shall be tapped lightly as with a finger or the eraser end of a pencil.

However, tapping is not permitted in certain tests such as those for determining intrinsic error, return to zero and the effects of shock and vibration, as stated in these test methods.

3.4 Thermal Stability

All instruments shall be allowed to remain at the reference temperature long enough to eliminate temperature gradients.

NOTE — Two hours will usually be sufficient.

3.5 Preconditioning Time

The provisions of **4.3.1** of IS 1248 (Part 1) shall apply.

3.6 Zero Adjustment (Mechanical)

With the instrument disconnected from all supplies and before each set of readings is taken, the index shall be set on the zero scale mark or to an appropriate reference mark on the scale using the mechanical zero adjuster, as follows:

a) Operate the zero adjuster in a direction, which will drive the index toward the zero mark of the instrument.

b) While continuing to drive the index in the direction selected in (a), set the index on the zero mark while tapping the instrument case. Once the direction of drive has been selected, do not change it until the index is on the zero mark.

c) With the index set on the zero mark, reverse the direction of motion of the zero adjuster, and drive it far enough to introduce mechanical freedom (play) in the zero adjuster, but not far enough to disturb the position of the index.

NOTE — Instruments without zero adjuster or where the mechanical zero does not appear on scale shall not be reset.

3.7 Zero Adjustment (Electrical)

Before each set of readings, the index shall be set on the reference mark with the electrical zero adjuster. Refer to the manufacturer's instructions for details of this adjustment.

3.8 Test Equipment Errors

All tests shall be made using reference instruments having an intrinsic error no more than one-fourth of that corresponding to the accuracy class of the instrument under test. However, the use of reference instrument having an intrinsic error no more than one-tenth of that corresponding to the accuracy class of the instrument under test is strongly recommended.

When testing for variations; avoid, if possible, applying the influence quantity (for example temperature) to the reference instrument. Otherwise, ensure that the reference instrument is not affected by more than one-fourth of the permissible variation of the instrument under test, where both are subjected to the same influence quantity (for example change of frequency).

Manufacturers shall make allowance for reference instrument uncertainty to ensure that all instruments are within their error limits at the time of shipment. In contrast, a user shall add the errors of his reference instrument to the permitted error when re-checking an instrument and the resulting sum shall be used for the limit for that test.

Nothing in these recommendations is intended to prevent the use of special test methods and/or specialized test equipment for making testing simpler and/or more accurate.

3.9 Reading Methods

Whenever possible, tests shall be conducted by setting the instrument under test to a scale mark and reading the reference instrument.

NOTE — The reference instrument should have an adequate scale resolution (or number of digits) to enable readings to be taken with a resolution at least as good as that corresponding to one-fifth of the accuracy class of the instrument under test.

3.10 Polyphase Testing

Polyphase instruments may be tested by connecting to an appropriate polyphase supply with properly measured and controlled voltages, currents and phase angles. If single-phase testing of polyphase instruments is permitted by the manufacturer, the current coils may be connected in series and the voltage coils in parallel. In all cases, follow the manufacturer's instructions for details of connections and the application of calibration constants.

3.11 a.c. Instrument Testing on d.c.

Some a.c. instruments, for example electrodynamic, thermal or electrostatic instruments, may be tested on d.c. if permitted by the manufacturer. If this is the case, perform the tests as specified for the instrument but use a d.c. supply and neglect references to power factor and phase angle. For these cases, the errors are computed from the average of the results from testing with the reversal of polarity of each measuring circuit. Other tests relating to ac variations may not apply.

3.12 Multirange and Multifunction Instruments

All ranges and all functions shall be tested separately. Instruments with multiple supply voltage capability shall be tested separately on each supply connections.

3.13 Test Leads

If test leads are specified by the manufacturer they shall be used for these tests. Otherwise, the size and placement of leads used in the performance of these tests shall be such that they do not influence the test results.

3.14 Ohmmeter Testing

For high value test resistors, the insulation of the test leads shall be adequate to ensure that the test resistor is not shunted to cause errors greater than one-tenth of the rated intrinsic error of the ohmmeter.

For low value resistors, the total resistance of the test leads shall be allowed for, unless it is negligible in comparison with the value of the test resistor.

Ohmmeters having special leads terminating in spikes may need special test resistors having terminals capable of accepting the spikes.

Ohmmeters measuring the value of 4-terminal resistors may need special test resistors.

Care shall be taken when testing high voltage ohmmeters, that the voltage rating of the test resistor is not exceeded. This is necessary both because of the danger of insulation breakdown and because of the possibility of the test resistor having a significant voltage coefficient.

If an ohmmeter has a stated value of test voltage when measuring a stated value of test resistance (or an open circuit), the voltage should be measured using a voltmeter having a permissible error not exceeding 5 percent of the test voltage. Where the voltage is to be measured at a definite value of test resistance, the voltmeter may be shunted to obtain this value.

Care shall be taken that the test resistor is not damaged by the current supplied by the ohmmeter.

When an ohmmeter has a hand-driven generator, it should be turned, as nearly as possible, at a uniform speed and at the speed stated by the manufacturer. If a slipping clutch is provided, the turning speed should be about 10 percent higher than the clutch slipping speed.

4 INTRINSIC ERROR TESTS

4.1 Ammeters and Voltmeters

4.1.1 *Procedure*

a) If relevant, set zero with tapping.
b) Apply sufficient slowly, increasing excitation to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping. Record the values of excitation (B_R) as shown by the reference instrument.
c) Increase the excitation to 120 percent of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less. Immediately and slowly reduce the excitation to bring the index sequentially to the same scale marks (B_X) as in (b) without tapping. Record the values of excitation (B_R) as shown by the reference instrument.

NOTE — For instrument in which the zero is displaced within the scale, these tests should be performed on both sides of the zero scale mark as appropriate.

4.1.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F}\right) \times 100$$

4.2 Wattmeters and Varmeters

4.2.1 *Procedure*

a) If relevant, set zero with tapping.
b) Energize the voltage circuits at rated voltage within ± 2 percent.
c) Apply sufficient slowly increasing current to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping. Record the values of excitation (B_R) as shown by the reference instrument.
d) Increase the current to 120 percent of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is less. Immediately and slowly reduce the current to bring the index sequentially to the same scale marks (B_X) as in (c) without tapping. Record the values of excitation (B_R) as shown by the reference instrument.

NOTE — For instruments, in which the zero is displaced within the scale, these tests should be performed on both sides of the zero scale mark as appropriate.

4.2.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F}\right) \times 100$$

4.3 Frequency Meters (Pointer Type)

4.3.1 *Procedure*

a) If relevant, set index to reference mark with tapping.
b) Apply rated voltage or a voltage at one of the limits of the reference range at a low frequency and slowly increase the frequency to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping, record the values of frequency (B_R) as shown by the reference instrument.
c) Increase the frequency to 120 percent of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less. Immediately and slowly reduce the frequency to bring the index sequentially to the same scale marks (B_X) as (b) without tapping.
   Record the values of frequency (B_R) as shown by the reference instrument.

4.3.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows :

$$\left(\frac{B_X - B_R}{A_F}\right) \times 100$$

4.4 Frequency Meters (Vibrating Reed Type)

4.4.1 *Procedure*

a) Apply rated voltage or a voltage at one of the limits of the reference range at the frequency required to bring the reed with the highest rating in that row (B_X) to resonate at its greatest amplitude and record the value of the frequency (B_R) as shown by the reference instrument.

b) Decrease the frequency to bring the reed with the next highest rating in that row (B_X) to resonate at its greatest amplitude and record the value of the frequency (B_R) as shown by the reference instrument.

c) Repeat (b) for each reed.

d) Repeat (a), (b) and (c) for each row if there is more than one row.

4.4.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed for each reed as follows:

$$\left(\frac{B_X - B_R}{A_F}\right)\times 100$$

4.5 Phasemeters

4.5.1 *Procedure*

a) If relevant, set zero with tapping.

b) Connect one of the measuring circuits to a source complying with the requirements of Table 1 of IS 1248 (Part 1) and Table 1 of IS 1248 (Part 5). Connect the other measuring circuit to a separate source. Both sources shall be set to the same frequency. The phase angle between the sources shall be adjustable and known.

c) Slowly adjust the phase difference between the two sources to zero and note the indication.

d) Carefully and slowly increase the phase difference to bring the index sequentially to each of at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range without tapping. Record the values of phase difference (B_R) as shown by the reference instrument.

e) Increase the phase difference to 120 percent of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less, but only to the value corresponding to the upper limit of the measuring ranges for instruments which cannot indicate beyond such limit. Immediately and slowly reduce the phase difference to bring the index sequentially to the same scale marks as in (d) without tapping. Record the values of phase difference (B_R) as shown by the tapping instrument.

For phasemeters capable of continuous 360° rotation, (d) shall be conducted in a clockwise direction and shall then be repeated in a counterclockwise direction. (e) shall be omitted.

4.5.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F}\right)\times 100$$

4.6 Power Factor Meters

4.6.1 *Procedure*

a) If relevant, set zero with tapping.

b) Connect the voltage circuit to a voltage source complying with the requirements of Table 1 of IS 1248 (Part 1) and Table 1 of IS 1248 (Part 5). Connect the current circuit to a separate source of current. Both sources shall be set to the same frequency. The phase angle between the sources shall be adjustable and known.

c) Apply 100 percent of rated current to the current circuit.

d) Carefully and slowly increase the phase difference to bring the index sequentially to at least five approximately equidistant scale marks (B_X) including the lower and upper limits of the measuring range, without tapping. Record the values of power factor (B_R) as shown by the reference instrument.

e) Increase the phase difference to 120 percent of the value corresponding to the upper limit of the measuring range or to cause the index to reach the upper limit of its travel, whichever is the less, but only to the value corresponding to the upper limit of the measuring ranges for instruments which cannot indicate beyond such limit. Immediately and slowly reduce the phase difference to bring the index sequentially to the same scale marks as in (d) without tapping. Record the values of phase difference (B_R) as shown by the reference instrument.

f) Repeat the test using 40 percent of rated current in the current circuit.

For power factor meters capable of continuous 360° rotation, (d) shall be conducted in a clockwise direction and then shall be repeated in a counterclockwise direction. (e) shall be omitted.

4.6.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F}\right)\times 100$$

4.7 Synchroscopes

4.7.1 *Procedure*

a) Connect both the incoming and the running circuits to separate voltage sources equal to the rated voltages for the instrument at rated frequency.

b) Adjust the phase difference between the incoming and running circuits to bring the index to the synchronizing mark. Record the phase difference (B_D) as shown by the reference instrument.

NOTE — The incoming circuit is that circuit which, in use, is normally connected to a source whose phase relative to another circuit, the running circuit, is to be adjusted so as to enable them to be synchronized.

4.7.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed as follows:

$$\left(\frac{B_D}{A_F}\right)\times 100$$

4.8 Ohmmeters

4.8.1 *Procedure*

a) The condition of the battery(ies), if any, shall be in accordance with the manufacturer's statements.

b) If relevant, set mechanical zero with tapping.

c) Carry out any preliminary adjustments that are specified by the manufacturer.

d) Determine the error of the ohmmeter by connecting it sequentially to known values of a test resistor. The uncertainty in the knowledge of the values of the test resistor should be preferably one-tenth or less of the permissible error of the ohmmeter at that value.

Where possible, use an adjustable resistor (for example, a multi-decade resistance box) as the test resistor and adjust it to bring the index sequentially to each of the numbered scale marks (B_X) without tapping. Record the values of the test resistor (B_R).

4.8.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed for each selected scale mark as follows:

$$\left(\frac{B_X - B_R}{A_F}\right)\times 100$$

4.9 Interchangeable Shunts

4.9.1 *Procedure*

a) Connect high current leads to the shunt of a size suitable for the rated current using the connection method intended by the manufacturer. If the shunt is intended for installation in a busbar, the test installation shall include a similar busbar configuration with the shunt mounted in the intended position of use.

b) Apply rated current, or rated current adjusted for the current drawn by the measuring instrument, through the shunt and record the voltage drop (B), as shown by the reference instrument. The rated current shall be d.c. unless a frequency is stated. If the shunt may be used on both ac and dc, separate tests shall be performed.

4.9.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed as follows:

$$\left(\frac{B - A_F}{A_F}\right)\times 100$$

4.10 Interchangeable Series Resistors (Impedances)

4.10.1 *Procedure*

a) Connect the resistor (impedance) in series with a suitable current measuring instrument whose internal impedance is negligible compared with the resistor (impedance) under test.

b) Apply rated voltage across the resistor (impedance) in series with the current measuring instrument. Record the value of the current (B), as shown by the reference instrument. The rated voltage shall be d.c. unless a frequency is stated. If the resistor (impedance) may be used on both a.c. and d.c., separate tests shall be performed.

4.10.2 *Computation*

The intrinsic error, expressed as a percentage, shall be computed as follows:

$$\left(\frac{A_F - B}{A_F}\right) \times 100$$

5 VARIATION TESTS

5.1 Variation due to ferromagnetic supports for instruments not marked with symbols F-37, F-38 or F-39 of IS 1248 (Part 1).

5.1.1 *Fixed Instruments*

5.1.1.1 *Procedure*

a) Mount the instrument on a non-ferromagnetic panel of any thickness at least 1 m from any ferromagnetic material.

b) Record the values of the excitation (B_A), as shown by the reference instrument, under reference conditions to bring the index sequentially to each of least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.

c) Mount the instrument in a similar manner on a 2 ± 0.5 mm thick demagnetized ferrous panel. The cutout in the panel shall be of the dimensions specified by the manufacturer.

d) Record the values of the excitation (B_B) to bring the index to the same scale marks as in (b) with tapping.

5.1.1.2 *Computation*

The variation, expressed as a percentage, due to ferromagnetic supports shall be computed at each selected scale mark as follows:

$$\left(\frac{B_A - B_B}{A_F}\right) \times 100$$

5.1.2 *Portable Instruments*

5.1.2.1 *Procedure*

a) Place the instrument in the reference position on a non-ferromagnetic surface at least 1 m from any ferromagnetic material.

b) Record the values of the excitation (B_A), as shown by the reference instrument, under reference conditions to bring the index sequentially to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.

c) Place the instrument, still in the reference position, on a demagnetized ferrous plate which is at least 6 mm thick, but for convenience limited to 10 mm and which extends at least 150 mm beyond the instrument on all sides.

d) Record the values of the excitation (B_B) to bring the index to the same scale marks as in (b) with tapping.

NOTE — For instruments that may be used in multiple positions, the limit positions and the middle position of the range should be tested.

5.1.2.2 *Computation*

The variation, expressed as a percentage, due to ferromagnetic platform shall be computed for each selected scale mark as follows:

$$\left(\frac{B_A - B_B}{A_F}\right) \times 100$$

5.2 Variation Due to Ambient Temperature

5.2.1 *Procedure*

a) Set the zero and record the values of the excitation (B_R), as shown by the reference instrument, under reference conditions to bring the index to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping. If a reference range for temperature is specified, the upper limit of the reference range shall be used.

b) Subject the instrument to a temperature equal to the upper limit of the nominal range of use above the reference temperature until thermal stability is attained but for not less than 2 h. Record the values of the excitation (B_X) to bring the index to the same scale marks as in (a) with tapping.

c) Condition the instrument at the reference temperature until thermal stability is attained but for not less than 2 h. Record the values of excitation (B_T) to bring the index to the same scale marks as in a) with tapping. If a reference range for temperature is specified, the lower limit of the reference range shall be used.

d) Subject the instrument to a temperature equal to the lower limit of the nominal range of use below the reference temperature until thermal stability is attained but for not less than 2 h. Record the values of the excitation (B_Y) to bring the index to the same scale marks as in (a) with tapping.

5.2.2 *Computation*

The variation, expressed as a percentage, at the upper limit of the nominal range of use shall be computed for each selected scale mark as follows:

$$\left(\frac{B_R - B_X}{A_F}\right)\times 100$$

A similar computation shall be made for the readings at the lower limit of the nominal range of use, as follows:

$$\left(\frac{B_T - B_Y}{A_F}\right)\times 100$$

If the absolute values of the variations above and below the reference temperature are not equal, the greater absolute value together with the appropriate sign shall be considered to be the temperature variation.

5.3 Variation Due to Humidity

5.3.1 *Procedure*

a) Set zero and record the values of the excitation (B_A), as shown by the reference instrument, under reference conditions, to bring the index to at least five approximately equidistant scale marks, including the upper and lower limits of the measuring range, with tapping.
b) Subject the instrument to a relative humidity of 25 percent to 30 percent for at least 16 h.
c) Set zero and record the values of the excitation (B_B) to bring the index to each of the same scale marks as in (a) with tapping.
d) Subject the instrument to a relative humidity of 75 percent of 80 percent for at least 16 h.
e) Set zero and record the values of the excitation (B_C) to bring the index to each of the same scale marks as in (a) with tapping.

5.3.2 *Computation*

The variation, expressed as a percentage, due to humidity at each selected scale mark shall be the maximum absolute value of the variation together with the appropriate sign. Computation is as follows:

$$\left(\frac{B_A - B_B}{A_F}\right)\times 100 \quad \text{or} \quad \left(\frac{B_A - B_C}{A_F}\right)\times 100$$

5.4 Variation Due to Position

5.4.1 Instruments Marked with Symbols **D-1** to **D-6** of IS 1248 (Part 1).

5.4.1.1 *Procedure*

a) Place the instrument in the marked position.
b) Record the values of the excitation (B_R), as shown by the reference instrument, under reference conditions to bring the index to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.
c) Tilt the instrument forward 5° or the value marked. Set zero and record the values of the excitation (B_W) to bring the index to each of the same scale marks as in step with tapping.
d) Tilt the instrument back 5° or the value marked. Set zero and record the values of the excitation (B_X) to bring the index to each of the same scale marks as in (b) with tapping.
e) Tilt the instrument to the left 5° or the value marked. Set zero and record the values of the excitation (B_Y) to bring the index to each of the same scale marks as in (b) with tapping.
f) Tilt the instrument to the right 5° or the value marked. Set zero and record the values of the excitation (B_Z) to bring the index to each of the same scale marks as in (b) with tapping.

5.4.1.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to position for each selected scale mark shall be the maximum deviation of the values given in **5.4.1.1** (b) from the corresponding values determined in **5.4.1.1** (c) to **5.4.1.1** (f) and shall be computed as follows:

$$\left(\frac{B_R - B_W}{A_F}\right)\times 100 \qquad \left(\frac{B_R - B_X}{A_F}\right)\times 100$$

$$\left(\frac{B_R - B_Y}{A_F}\right)\times 100 \quad \text{and} \quad \left(\frac{B_R - B_Z}{A_F}\right)\times 100$$

5.4.2 *Instruments Without Position Marking*

5.4.2.1 *Procedure*

a) Place the instrument in the reference position.
b) Record the values of the excitation (B_R), as shown by the reference instrument, under reference conditions to bring the index sequentially to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.
c) Tilt the instrument 90°, that is, for fixed instruments with the mounting plane

horizontal, for portable instruments with the supporting plane vertical. Set zero and record the values of the excitation (B_W) to bring the index to each of the same scale marks as in (b) with tapping.

5.4.2.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to position for each selected scale mark shall be the maximum deviation of the values in **5.4.2.1** (c) from the corresponding value determined in **5.4.2.1** (b) and shall be computed as follows:

$$\left(\frac{B_R - B_W}{A_F}\right) \times 100$$

5.5 Variation Due to Magnetic Field of External Origin

5.5.1 *Procedure for Instruments*

a) Record the values of the excitation (B_R), as shown by the reference instrument, under reference conditions to bring the index sequentially to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping. For permanent magnet moving coil, thermal and ferrodynamic instruments, only one measurement at the upper limit of the measuring range shall be made.

b) Subject the instrument to a magnetic field of external origin of 0.4 kA/m produced by a current of the same kind and frequency as that which actuates the mechanism. The field shall be produced by a coil of 1 m mean diameter, of square cross-section and of radial thickness small compared with the diameter. In this coil, 400 ampere-turns will produce a field of approximately 0.4 kA/m. The instrument under test shall be placed in the centre of the coil. The variation shall be determined by incrementally rotating the coil and changing the phase of the external magnetic field to produce the greatest variation.

   An instrument having any external dimension exceeding 250 mm shall be tested in a coil of mean diameter not less than four times the maximum dimension of the instrument. The current shall be such as to produce a magnetic field having, at its centre, the value specified above.

   NOTE — By agreement between the manufacturer and the user, other devices which produce an adequate homogeneous magnetic field (for example, Helmholts coils) are also permissible.

c) Repeat (a) under the most unfavorable conditions as determined in step (b) and record the value(s) (B_X).

NOTES

1 Wattmeters, varmeters, phasemeters, synchroscopes and power factor meters should have rated voltage applied to the voltage applied to the voltage circuit(s). For wattmeters and varmeters, the current applied should be at reference power factor.

2 The magnetic field is reduced for frequencies between 1 kHz and 20 kHz by the factor 1/*f*, where *f* is the frequency in kilohertz. Above 20 kHz no test is specified.

3 For instruments marked with symbol F-30, the external magnetic field to be used for this test should be that value marked on the instrument instead of the 0.4 kA/m specified in this test method.

5.5.2 *Procedure for Accessories*

a) Apply rated excitation to the accessory connected to a measuring instrument so that an appropriate indication is produced and record the value of the excitation (B_R), as shown by the reference instrument.

b) Subject the accessory to a magnetic field of external origin of 0.4 kA/m produced by a current of the same kind and frequency as that which excites the accessory. The field shall be produced by the apparatus described in **5.4.1** (b).

c) Apply sufficient excitation to the accessory connected as in (a) to produce the same indication of the measuring instrument as in (a) under the most unfavourable conditions as determined by (b) and record the value of the excitation (B_X). Do not subject the reference or measuring instruments to a magnetic field of external origin.

NOTES

1 The magnetic filed is reduced for frequencies between 1 kHz and 20 kHz by the factor 1/*f*, where *f* is the frequency in kilohertz. Above 20 kHz no test is specified.

2 For accessories marked with symbol F-30, the external magnetic field to be used for this test should be that value marked on the accessory instead of the 0.4 kA/m specified in this test method.

3 Accessories of limited interchangeability and non-interchangeable accessories may have to be tested together with their instruments.

5.5.3 *Computation*

The absolute value of the variation, expressed as a percentage, due to external magnetic field shall be maximum deviation computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

5.6 Variation Due to Ripple on d.c. Measured Quantity

5.6.1 *Procedure for Instruments*

a) Connect a reference instrument having a negligible ripple error, and apply a d.c. excitation which will bring the index of the instrument under test to a scale mark near 80 percent of the upper limit of its measuring range. Record the value of the excitation (B_R), as shown by the reference instrument.

b) While holding the d.c. excitation constant, superimpose a 45 Hz ripple voltage or current equal to the marked value or 20 percent of the value of the d.c. excitation. Slowly increase the frequency to 65 Hz to find the frequency, which produces the maximum change in indication. Then change the d.c. excitation to produce the same indication as in (a). Record the value of the excitation (B_X), as shown by the reference instrument.

c) Repeat (b) using a ripple frequency of 90 Hz to 130 Hz and record (B_Y) in the same manner.

NOTE — When the ripple component of the excitation causes an oscillation of the index, the mean value of its excursion should be used as the indication.

5.6.2 *Procedure for Accessories*

a) Connect a reference instrument having negligible ripple error and apply a d.c. excitation to the accessory equal to 80 percent of its rated value while connected to a measuring instrument having a negligible ripple error such that an appropriate indication is produced and record the value of the excitation (B_R), as shown by the reference instrument.

b) While holding the d.c. excitation constant, superimpose a 45 Hz ripple voltage or current equal to the marked value or 20 percent of the value of the d.c. excitation. Slowly increase the frequency to 65 Hz to find the frequency which produces the maximum change in indication of the measuring instrument. Then change the d.c. excitation to produce the same indication of the measuring instrument as in a) above. Record the value of the excitation (B_X), as shown by the reference instrument.

c) Repeat (b) using a ripple frequency of 90 Hz to 130 Hz and record (B_Y) in the same manner.

NOTE — When the ripple component of the excitation causes an oscillation of the index, the mean value of its excursion should be used as the indication.

5.6.3 *Computation*

The absolute value of the variation, expressed as a percentage, due to ripple on the d.c. measured quantity shall be maximum deviation computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right)\times 100 \quad \text{or} \quad \left(\frac{B_R - B_Y}{A_F}\right)\times 100$$

5.7 Variation Due to Distortion of a.c. Measured Quantity

5.7.1 *Procedure for Ammeters and Voltmeters*

a) Connect a reference instrument having a negligible waveform error, and apply sufficient sine-wave excitation (maximum distortion in accordance with Table 1 of IS 1248 (Part 1) to bring the index of the instrument under test to a scale mark near 80 percent of the upper limit of the measuring range. Record the value of the excitation (B_R), as shown by the reference instrument.

b) Superimpose the marked value or 20 percent of the value of the fundamental waveform of third harmonic upon the fundamental waveform and adjust amplitude of the distortion waveform to produce the same r.m.s. value on the reference instrument as was previously noted. Vary the phase difference between the fundamental and the third harmonic to achieve maximum influence on the instrument under test. Then change the amplitude of the distorted wave to produce the same indication as in (a) above. Record the value of the excitation (B_X), as shown by the reference instrument.

5.7.2 *Procedure for Frequency Meters*

a) Connect a reference instrument having a negligible waveform error, apply rated sine-wave voltage (maximum distortion in accordance with Table 1 of IS 1248 (Part 1) and adjust the frequency to bring the index of the instrument under test to a scale mark near mid-scale. Record the value of the frequency (B_R), as shown by the reference instrument.

b) Superimpose the marked value or 15 percent of the value of the fundamental waveform of the third harmonic upon the fundamental waveform and adjust the amplitude of the distorted wave to produce the rated r.m.s. voltage. At fundamental frequency (B_R) vary the phase difference between the fundamental and the third harmonic to achieve maximum influence on the instrument under test. Adjust the frequency to produce indication at the same scale mark as in (a) above and record the value of the frequency (B_X), as shown by the reference instrument.

5.7.3 *Procedure for Wattmeters and Varmeters*

a) Connect a reference instrument having negligible waveform error, and apply sufficient sine-wave excitation (maximum distortion in accordance with Table 1 of IS 1248 (Part 1) at rated voltage to bring the index of the instrument under test to a scale mark near 80 percent of the upper limit of the measuring range. Record the value of the excitation (B_R), as shown by the reference instrument.

b) With rated sine-wave excitation on one of the measuring circuits, apply distorted excitation to the other measuring circuit consisting of the fundamental waveform with a superimposed third harmonic waveform equal to 20 percent of the value of the fundamental waveform (5 percent for instruments using phase shifting devices or the marked value if the instrument is so marked). Adjust the amplitude of the distorted waveform to produce the same indication on the reference instrument as in (a). Vary the phase difference between the fundamental and the third harmonic waveforms to produce the maximum influence on the instrument under test. Then change the amplitude of the distorted wave to produce the same indication as in (a). Record the value of the excitation (B_X), as shown by the reference instrument.

c) Repeat (b) above with the two measuring circuits inter-changed.

5.7.4 *Procedure for Phasemeters, Power Factor Meters and Synchroscopes*

a) Connect a reference instrument having negligible waveform error, apply rated sine-wave excitation (maximum distortion in accordance with Table 1 of IS 1248 (Part 1) and adjust the phase angle between the two circuits to bring the index of the instrument under test to the zero, unity power factor or synchronizing scale mark. Record the value of the phase angle (B_R), as shown by the reference instrument.

b) With rated sine-wave excitation on one of the measuring circuits, apply distorted excitation to the other measuring circuit consisting of the fundamental waveform with a superimposed third harmonic waveform equal to 20 percent of the value of the fundamental waveform (5 percent for instruments using phase shifting devices or the marked value if the instrument is so marked). The r.m.s. value of the distorted waveform shall be the rated value of excitation for that measuring circuit. Vary the phase difference between the fundamental and the third harmonic waveform to produce the maximum influence on the instrument under test. Then adjust the phase difference between the sine-wave excitation on one of the measuring circuits and the fundamental of the distorted waveform applied to the other measuring circuit to produce the same indication as in (a). Record the value of the phase angle (B_X), as shown by the reference instrument.

c) Repeat (b) above with the two measuring circuits interchanged.

5.7.5 *Procedure for Accessories*

a) Connect a reference instrument having negligible waveform error to the accessory, apply a sine-wave excitation (maximum distortion in accordance with Table 1 of IS 1248 (Part 1) to the accessory equal to approximately 80 percent of its rated value while connected to a measuring instrument having negligible waveform error such that an appropriate indication is produced and record the value of the excitation (B_R), as shown by the reference instrument.

b) Superimpose the marked value or 20 percent of the value of the fundamental waveform of the third harmonic upon the fundamental waveform and adjust the amplitude of the distorted waveform to produce the same indication on the reference instrument as in (a). Vary the phase difference between the fundamental and the third harmonic waveform to produce the maximum change in indication of the measuring instrument. Then change amplitude of the distorted wave to produce the same indication of the measuring instrument as in (a). Record the value of the excitation (B_X), as shown by the reference instrument.

5.7.6 *Computation*

The variation, expressed as a percentage, due to distortion of a.c. measured quantity shall be computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

5.8 Variation Due to Frequency of a.c. Measured Quantity

If any of the tests of this sub-clause require a value of excitation exceeding the maximum permitted value for the instrument under test, a lower value shall be selected.

5.8.1 *Variation for Ammeters, Voltmeters, Wattmeters and Varmeters*

5.8.1.1 *Procedure*

a) Record the values of the excitation (B_R), as shown by the reference instrument, under reference conditions to bring the index sequentially to each of at least five approximately equidistant scale marks including the upper and lower limits of the measuring range with tapping.

b) Vary the frequency of the excitation within the limits shown in the relevant parts and repeat (a) at each frequency deviation. Record the values of the excitation (B_X). For wattmeters and varmeters, the variation shall be determined at reference power factor.

c) For wattmeters and varmeters only, adjust the power factor to the lower limit (lagging) of its nominal range of use and repeat (b).

5.8.1.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to frequency of ac measured quantity shall be the greatest of the values computed for each selected scale mark as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

5.8.2 *Variation for Phasemeters*

5.8.2.1 *Procedure*

a) Energize both inputs at their reference frequency and at their rated voltage and/or current. With tapping, adjust the phase difference between the two inputs to produce a zero indication and record the value of the phase difference (B_{AN}), as shown by the reference instrument.

b) With the frequency of both inputs at the lower limit of the nominal range of use, adjust the phase difference to produce the same indication as in (a) and record the value of the phase difference (B_{AL}).

c) With the frequency of both inputs at the upper limit of the nominal range of use, adjust the phase difference to produce the same indication as in (a) and record the value of the phase difference (B_{AU}).

d) Adjust the phase difference between the two inputs to produce an indication at 90° and record the value of the phase difference (B_{BN}). Repeat (b) and (c). Record the values of the phase differences (B_{BL}) and (B_{BU}).

e) Adjust the phase difference between the two inputs to produce an indication at 180° and record the value of the phase difference (B_{CN}). Repeat (b) and (c). Record the values of the phase difference (B_{CL}) and (B_{CU}).

f) Adjust the phase difference between the two inputs to produce an indication at 270° and record the value of the phase difference (B_{DN}). Repeat (b) and (c). Record the values of the phase differences (B_{DL}) and (B_{DU}).

NOTE — if the instrument has a narrow measuring range, omit the tests which are at indications outsides the measuring range but carry out tests at the limits of the measuring range.

5.8.2.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to frequency of ac measured quantity shall be the greatest of the values computed for each selected scale mark as follows:

At the lower limit of frequency, $\left(\frac{B_{XN} - B_{XL}}{A_F}\right) \times 100$

At the upper limit of frequency, $\left(\frac{B_{XN} - B_{XU}}{A_F}\right) \times 100$

5.8.3 *Variation for Power Factor Meters*

5.8.3.1 *Procedure*

NOTE — All phase differences are measured in angular degrees.

a) At reference frequency, energize the current circuit at approximately half its rated value.

b) At the same (reference) frequency, energize the voltage circuit at its rated voltage. With tapping, adjust the phase difference between the current and voltage circuits to produce a power factor indication of unity. Record the value of the phase difference (B_{AN}), as shown by the reference instrument.

c) Decrease the frequency of both inputs to the lower limit of the nominal range of use for frequency. Adjust the phase difference between the current and voltage circuits to produce the same indication as in (b). Record the value of the phase difference (B_{AL}).

d) Increase the frequency of both inputs to the upper limit of the nominal range of use for frequency. Adjust the phase difference between the current and voltage circuits to produce the same indication as in (b). Record the value of the phase difference (B_{AU}).

e) Adjust the phase difference between the current and voltage circuits to produce a power factor indication of 0.5 lagging. Record the value of the phase difference (B_{BN})

f) Repeat (c) and (d) but producing the same indication as in (e). Record the values of the phase differences (B_{BL}) and (B_{BU}).

g) Adjust the phase difference between the current and voltage circuits to produce a power factor indication of 0, the current lagging behind the voltage by about 90°. Record the value of the phase difference (B_{CN}).

h) Repeat (c) and (d) but producing the same indication as in (g). Record the values of the phase differences (B_{CL}) and (B_{CU}).

j) Adjust the phase difference between the current and voltage circuits to produce a power factor indication of 0.5 leading. Record the value of the phase difference (B_{DN}).

k) Repeat (c) and (d) but producing the same indication as in (j). Record the values of the phase differences (B_{DL}) and (B_{DU}).

NOTE — If the instrument has a narrow measuring range, omit the tests, which are at indications outside the measuring range but carry out tests at the limits of the measuring range.

5.8.3.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to the frequency of ac measured quantity shall be the greatest of the values computed for each selected scale mark as follows:

At the lower limit of frequency, $\left(\frac{B_{XN}-B_{XL}}{A_F}\right)\times 100$

At the upper limit of frequency, $\left(\frac{B_{XN}-B_{XU}}{A_F}\right)\times 100$

5.8.4 *Variation for Synchroscopes*

5.8.4.1 *Procedure*

NOTE — All phase differences are measured in angular degrees.

a) Energize both input circuits at the reference voltage and frequency. Adjust the phase difference between the two voltages to bring the index to the synchronizing mark. Measure and record the value of the phase difference (B_R) as shown by the reference instrument.

b) Decrease the frequency of both circuits to the lower limit of the nominal range of use for frequency. Adjust the phase difference between the two voltages to bring the index to the synchronizing mark. Measure and record the value of the phase difference (B_l) as shown by the reference instrument.

c) Increase the frequency of both circuits to the upper limit of the nominal range of use for frequency. Adjust the phase difference between the two voltages to bring the index to the synchronizing mark. Measure and record the value of the phase difference (B_U) as shown by the reference instrument.

5.8.4.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to frequency of a.c. measured quantity shall be the greatest of the values computed as follows:

At the lower limit of frequency, $\left(\frac{B_R-B_L}{A_F}\right)\times 100$

At the upper limit of frequency, $\left(\frac{B_R-B_U}{A_F}\right)\times 100$

5.8.5 *Variation for Accessories*

5.8.5.1 *Procedure*

a) Connect a reference instrument having a negligible frequency error to the accessory and apply sufficient excitation at reference frequency to operate the accessory at approximately 80 percent of its rated value while connected to measuring instrument so that the instrument displays an indication at an appropriate scale mark and record the value of the excitation (B_R), as shown by the reference instrument.

b) Vary the frequency of the excitation within the limit shown in Table 2 of IS 1248 (Part 8) and repeat step (a) at each frequency deviation. Record the value of the excitation (B_X) required to bring the indication of the indicating instrument to the same scale mark as in (a).

5.8.5.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to frequency of a.c. measured quantity shall be the greatest of the values computed as follows:

$$\left(\frac{B_R-B_X}{A_F}\right)\times 100$$

5.9 Variation Due to Voltage/Current Component of the a.c. Measured Quantity

5.9.1 *Variation for Wattmeters and Varmeters*

5.9.1.1 *Procedure*

a) At rated voltage and reference power factor, adjust the excitation to produce an indication at a scale mark near 80 percent of the upper limit of the measuring range. Record the value of the excitation (B_R), as shown by the reference instrument.

b) Repeat (a) but adjust the voltage to the lower limit of its nominal range of use and adjust the excitation to produce the same indication. Record the value of the excitation (B_L), as shown by the reference instrument.

c) Change the voltage to the upper limit of its nominal range of use and adjust the excitation to produce the same indication as in (a). Record the value of the excitation (B_U), as shown by the reference instrument.

5.9.1.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to voltage/current component of the measured quantity shall be the greater of the values computed as follows:

At the lower limit of frequency, $\left(\frac{B_R - B_L}{A_F}\right) \times 100$

At the upper limit of frequency, $\left(\frac{B_R - B_U}{A_F}\right) \times 100$

5.9.2 *Variation for Frequency Meters*

5.9.2.1 *Procedure*

a) Energize the instrument at its rated voltage at a frequency to produce an indication at a scale mark near the middle of the measuring range. Record the value of the frequency (B_R), as shown by the reference instrument.

b) Decrease the voltage to the lower limit of its nominal range of use and adjust the frequency to produce the same indication as in (a). Record the value of the frequency (B_L), as shown by the reference instrument.

c) Increase the voltage to the upper limit of its nominal range of use and adjust the frequency to produce the same indication as in (a). Record the value of the frequency (B_U), as shown by the reference instrument.

d) Repeat (a) to (c) for indications at the lower and upper limits of the measuring range.

5.9.2.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to voltage of a.c. measured quantity shall be the greatest of the values computed as follows:

At the lower limit of voltage, $\left(\frac{B_R - B_L}{A_F}\right) \times 100$

At the upper limit of voltage, $\left(\frac{B_R - B_U}{A_F}\right) \times 100$

5.9.3 *Variation for Phasemeters*

5.9.3.1 *Procedure*

a) Energize one of the measuring circuits at its rated voltage or current at reference frequency.

b) Energize the other measuring circuit at a voltage or current equal to its rated voltage or current at reference frequency. Adjust the phase difference between the two measuring circuits to produce an indication at 0°, 90°, 180° and 270° in sequence. Record the values of the phase differences (B_R), as shown by the reference instrument.

c) Decrease the voltage or current applied in (b) to the lower limit of the nominal range of use. Vary the phase difference between the two measuring circuits to produce an indications at the same scale marks as in (b). Record the values of the phase differences (B_L).

d) Increase the voltage or current applied in (b) to the upper limit of the nominal range of use. Vary the phase difference between the two measuring circuits to produce an indication at the same scale marks as in (b). Record the values of the phase differences (B_U).

e) Interchange the two measuring circuits and repeat (c) and (d) so that the first measuring circuit is tested at the lower and upper limits of its nominal range of use while the second measuring circuit is maintained at its rated excitation.

NOTE — If the instrument has a narrow measuring range, omit the tests which are at indications outside the measuring range but carry out tests at the limits of the measuring range.

5.9.3.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to voltage or current component of a.c. measured quantity shall be the greatest of the values computed for each selected scale mark as follows:

$$\left(\frac{B_R - B_L}{A_F}\right)\times 100 \quad \text{or} \quad \left(\frac{B_R - B_U}{A_F}\right)\times 100$$

5.9.4 *Variation for Power Factor Meters*

5.9.4.1 *Variation due to the voltage component of the ac measured quantity*

5.9.4.1.1 *Procedure*

NOTE — All phase differences are measured in angular degrees.

a) At reference frequency, energize the current circuit at approximately half its rated value.

b) At the same (reference) frequency, energize the voltage circuit at its rated voltage. Adjust the phase difference between the current and voltage circuits to produce a power factor indication of unity. Record the value of the phase difference (B_{AN}) as shown by the reference instrument.

c) At the same (reference) frequency and leaving the current unaltered, decrease the applied voltage to the lower limit of the nominal range of use for voltage. Adjust the phase difference between the current and voltage circuits to produce the same indication as in (b). Record the value for the phase difference (B_{AL}) as shown by the reference instrument.

d) At the same (reference) frequency and leaving the current unaltered, increase the applied voltage to the upper limit of the nominal range of use for voltage. Adjust the phase difference between the current and voltage circuits to produce the same indication as in (b). Record the value of the phase difference (B_{AU}) as shown by the reference instrument.

e) Repeat (b), (c) and (d) but adjusting the phase difference to produce a power factor indication of 0.5 lagging in each case. Record the values of these phase differences (B_{BN}), (B_{BL}) and (B_{BU}) as shown by the reference instrument.

f) Repeat (b), (c) and (d), but adjusting the phase difference between the current and voltage circuits to produce a power factor indication of 0, the current lagging behind the voltage by about 90° in each case. Record the values of these phase differences (B_{CN}), (B_{CL}) and (B_{CU}) as shown by the reference instrument.

g) Repeat (b), (c) and (d) but adjusting the phase difference between the current and voltage circuits to produce a power factor indication of 0, the current leading the voltage by about 90° in each case. Record the values of these phase difference (B_{DN}), (B_{DL}) and (B_{DU}) as shown by the reference instrument.

h) Repeat (b), (c) and (d) but adjusting the phase difference between the current and voltage circuits to produce a power factor indication of 0.5 leading in each case. Record the values of these phase differences (B_{EN}), (B_{EL}) and (B_{EU}) as shown by the reference instrument.

NOTE — If the instrument has a narrow measuring range, omit the tests which are at indications outside the measuring range but carry out tests at the limits of the measuring range.

5.9.4.2 *Computation*

The absolute value, expressed as a percentage, of the variation due to the voltage component of the a.c. measured quantity shall be the greatest of the values computed for each selected power factor as follows:

$$\left(\frac{B_{XN} - B_{XL}}{A_F}\right)\times 100 \quad \text{or} \quad \left(\frac{B_R - B_{XU}}{A_F}\right)\times 100$$

5.9.4.3 *Variation Due to the Current Component of the a.c. Measured Quantity*

5.9.4.3.1 *Procedure*

NOTE — All phase differences are measured in angular degrees.

a) At reference frequency, energize the voltage circuit at its rated value.

b) At the same (reference) frequency, energize the current circuit at its rated current. Adjust the phase difference between the current and voltage circuits to produce a power factor indication of unity. Record the value of the phase difference (C_{AN}) as shown by the reference instrument.

c) At the same (reference) frequency and leaving the voltage unaltered, decrease the applied current to the lower limit of the nominal range of use for current. Adjust the phase difference between the current and voltage circuits to produce the same indication as in (b). Record the value of the phase difference (C_{AL}) as shown by the reference instrument.

d) At the same (reference) frequency and leaving the voltage unaltered, increase the applied current to the upper limit of the nominal range of use for current. Adjust the phase difference between the current and voltage circuits to produce the same indication as in (b). Record the value of the phase difference (C_{AU}) as shown by the reference instrument.

e) Repeat (a), (b) and (c) but adjusting the phase difference to produce a power factor indication of 0.5 lagging in each case. Record the values of these phase differences (C_{BN}),

(C_{BL}) and (C_{BU}) as shown by the reference instrument.

f) Repeat (b), (c) and (d) but adjusting the phase difference between the current and voltage circuits to produce a power factor indication of 0, the current lagging behind the voltage by about 90° in each case. Record the values of these phase differences (C_{CN}), (C_{CL}) and (C_{CU}) as shown by the reference instrument.

g) Repeat (b), (c) and (d) but adjusting the phase difference between the current and voltage circuits to produce a power factor indication of 0, the current leading the voltage by about 90° in each case. Record the values of these phase differences (C_{DN}), (C_{DL}) and (C_{DU}) as shown by the reference instrument.

h) Repeat (b), (c) and (d) but adjusting the phase difference between the current and voltage circuits to produce a power factor indication of 0.5 leading in each case. Record the values of these phase differences (C_{EN}), (C_{EL}) and (C_{EU}) as shown by the reference instrument.

NOTE — If the instrument has a narrow measuring range, omit the tests which are at indications outside the measuring range but carry out tests at the limits of the measuring range.

5.9.4.4 *Computation*

The absolute value, expressed as a percentage, of the variation due to the current component of the a.c. measured quantity shall be the greatest of the values computed for each selected power factor as follows:

$$\left(\frac{C_{XN}-C_{XL}}{A_F}\right)\times 100 \quad \text{or} \quad \left(\frac{C_{XN}-C_{XU}}{A_F}\right)\times 100$$

5.9.5 *Variation for Synchroscopes*

5.9.5.1 *Procedure*

a) Energize the running circuit at its rated voltage and reference frequency.

b) Energize the incoming circuit at its rated voltage and reference frequency and adjust the phase difference with the running circuit to bring the index to the synchronizing mark. Record the value of the phase difference (B_R) as shown by the reference instrument.

c) Decrease the voltage applied to the incoming circuit to the lower limit of its nominal range of use and adjust the phase difference with the running circuit to bring the index to the synchronizing mark. Record the value of the phase differences (B_{SL}).

d) Increase the voltage in (c) to a voltage equal to the upper limit of its nominal range of use and adjust the phase difference with the running circuit to bring the index to the synchronizing mark. Record the value of the phase difference (B_{SU}).

e) Decrease the voltage applied to the running circuit to the lower limit of its nominal range of use.

f) Repeat (c) and (d). Record the values of these phase differences (B_{LL}) and (B_{LU}).

g) Increase the voltage applied to the running circuit to the upper limit of its nominal range of use.

h) Repeat (c) and (d). Record the values of these phase differences (B_{UL}) and (B_{UU}).

NOTE — The 'incoming circuit' is that circuit which, in use, is normally connected to a source whose phase relative to another circuit, the 'running circuit', is to be adjusted so as to enable them to be synchronized.

5.9.5.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to the voltage component of the a.c. measured quantity shall be the greatest of the values computed as follows:

$$\left(\frac{B_R-B_{SL}}{A_F}\right)\times 100, \quad \left(\frac{B_R-B_{SU}}{A_F}\right)\times 100,$$
$$\left(\frac{B_R-B_{LL}}{A_F}\right)\times 100, \quad \left(\frac{B_R-B_{LU}}{A_F}\right)\times 100,$$
$$\left(\frac{B_R-B_{UL}}{A_F}\right)\times 100, \quad \left(\frac{B_R-B_{UU}}{A_F}\right)\times 100$$

5.10 Variation Due to Power Factor

5.10.1 *Variation for Wattmeters*

5.10.1.1 *Procedure*

a) Connect a reference wattmeter having a negligible power factor error and apply rated voltage and sufficient current at unity power factor and at the reference frequency to produce an indication at a scale mark near the middle of the measuring range. Record the value of the excitation (B_R) as shown by the reference wattmeter.

b) Repeat (a) at 0.5 power factor lagging (or the value given by the manufacturer). Record the value of the excitation (B_X) as shown by the reference wattmeter.

c) When required by Table 2 of IS 1248 (Part 3), repeat (a) at 0.5 power factor leading (or the value given by the manufacturer). Record the value of the excitation (B_Y) as shown by the reference wattmeter.

d) When required by the Table 2 of IS 1248

(Part 3), repeat (a) at 0 power factor lagging and leading. Record the values of the excitation (B_X) and (B_Y) as shown by the reference wattmeter.

5.10.1.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to the power factor shall be the greater of the values computed as follows:

At lagging power factor, $\left(\frac{B_R - B_X}{A_F}\right) \times 100$

At leading power factor, $\left(\frac{B_R - B_Y}{A_F}\right) \times 100$

5.10.2 *Variation for Varmeters*

5.10.2.1 *Procedure*

a) Apply rated voltage and sufficient current at a phase angle 90° lagging and at the reference frequency to produce an indication at a scale mark near the middle of the measuring range. Record the values of the voltage (V_R), current (I_R) and phase angle (ϕ_R) excitation, as shown by the reference instruments.

b) Repeat a) at a phase angle of 30° lagging (or the value given by the manufacturer if more than 30°). Record the values of the excitation (V_X), (I_X) and (ϕ_X) as shown by the reference instrument.

c) When required by Table 2 of IS 1248 (Part 3), apply rated voltage and sufficient current at a phase angle of 90° leading to produce an indication at a scale mark near the middle of the measuring range. Record the values of the voltage (V_R), current (I_R) and phase angle (ϕ_R) excitation, as shown by the reference instruments.

d) When required by Table 2 of IS 1248 (Part 3), repeat (c) at a phase angle of 30° leading (or the value given by the manufacturer if more than 30°). Record the values of the excitation (V_X), (I_X) and (φ_X) as shown by the reference instrument.

NOTE — As a laboratory type varmeter is not generally available for use as a reference instrument to make these tests, this procedure is based on the use of a high accuracy voltmeter, ammeter and phasemeter as reference instruments. For polyphase varmeters, a reference wattmeter may be used with cross phase connections in place of separate reference instruments. Refer to the manufacturer for connection instructions and the application of calibration constants.

5.10.2.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to lagging and leading power factor shall be the greater of the values computed as follows :

$$\left(\frac{V_R \cdot I_R \cdot \sin\phi_R - V_X \cdot I_X \cdot \sin\phi_X}{A_F}\right) \times 100$$

5.11 Variation Due to Battery Voltage

5.11.1 *Procedure for Ohmmeters*

a) Connect a regulated power supply as a substitute for the battery. Adjust the power supply voltage to the rated value of the battery. If the maximum internal resistance of the battery is specified by the manufacturer of the instrument, add a resistor in series with the power supply to bring its source resistance up to the specified value.

b) Make the preliminary adjustments that are specified by the manufacturer.

c) Record the value of the resistance (A_R) required to produce an indication of the ohmmeter at a scale mark at about mid-scale.

d) Adjust the power supply voltage to the lower limit of the battery voltage specified by the manufacturer.

e) Record the value of the resistance (A_L) required to produce an indication of the ohmmeter at the same scale mark as in (c).

f) Adjust the power supply voltage to the upper limit of the battery voltage specified by the manufacturer.

g) Record the value of the resistance (A_U) required to produce an indication of the ohmmeter at the same scale mark as in (c).

5.11.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to battery voltage is the greater of the values computed as follows:

$$\left(\frac{A_R - A_L}{A_F}\right) \times 100 \quad \text{or} \quad \left(\frac{A_R - A_U}{A_F}\right) \times 100$$

5.12 Variation Due to Unbalanced Currents

5.12.1 *Procedure for Polyphase Wattmeters and Varmeters*

a) At reference frequency, apply rated voltage(s). Vary the current(s) at unity power factor and record the value of the excitation (B_R) as shown by the reference instrument, required to produce an indication at a scale mark at approximately mid-scale for two-element instruments and at two-thirds scale (one-quarter scale for single phase testing) for two-and-a-half element and three-element instruments.

b) Disconnect one current circuit and apply sufficient current in the other current circuits to bring the index to the same indication as in (a). Record the value of the excitation (B_X).

c) Repeat (b) for each of the other current circuits.

5.12.2 *Procedure for Polyphase Power Factor Meters*

a) Apply rated voltage and current and vary the phase difference between the two input circuits to bring the index to a scale mark approximately at mid-scale with tapping. Record the value of that phase difference (B_R) as shown by the reference instruments.

b) Disconnect one current circuit and vary the phase difference to bring the index to the same scale mark as in (a). Record the value of that phase difference (B_X).

c) Repeat (b) disconnection each of the other current circuits one at a time.

5.12.3 *Computation*

The absolute value of the variation, expressed as a percentage, due to unbalanced current shall be the greatest of the values computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

5.13 Variation Due to Conductive Supports

5.13.1 *Procedure*

a) Mount the instrument on a conductive panel or place the instrument on a conductive support in the reference position. The conductive panel or conductive support shall be aluminium of 1.5 mm minimum thickness and shall extend beyond the instrument by at least 150 mm on all sides. The panel or support shall be connected to earth (ground).

b) Repeat the appropriate intrinsic error test with the instrument mounted as in (a).

5.13.2 *Computation*

The errors shall be computed as indicated for the appropriate intrinsic error test given in **4**.

5.14 Variation Due to Electric Field of External Origin

5.14.1 *Procedure for Electrostatic Instruments*

a) Apply sufficient excitation to bring the index to a scale mark approximately at the middle of the measuring range. Record the value of the excitation (B_R) as shown by the reference instrument.

b) Centre the instrument between a pair of parallel isolated discs. The diameter of the discs shall be at least 20 percent greater than the maximum dimension of the instrument under test. The separation of the discs shall be at least twice the maximum dimension of the instrument under test.

c) Apply a d.c voltage sufficient to produce an electric field between the discs as specified in **5.2.2** and Table 2 of IS 1248 (Part 1). The supply producing the electric field shall be earthed at its mid-point.

d) With the instrument housing, if conductive, and the signal low terminal at earth potential, apply sufficient excitation to bring the index to the same scale mark as in (a). Record the value of the excitation (B_X).

e) Repeat step (d) with the instrument oriented to produce the greatest variation.

f) Repeat (c), (d) and (e) using an a.c. voltage having a frequency between 45 Hz and 65 Hz applied between the discs to produce an electric field as specified in the relevant parts. The supply producing the electric field shall be connected to earth (ground) at its mid-point.

5.14.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to an electric field of external origin shall be the greatest of the values computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

5.15 Variation Due to Simultaneous Influence of Voltage and Power Factor

If any of the tests of this sub-clause require a value of current exceeding the maximum permitted value for the instrument under test, a lower initial value of power (active or reactive) shall be selected.

5.15.1 *Procedure for Wattmeters and Varmeters*

a) Energize the voltage circuits at their rated voltage and reference frequency.

b) Apply sufficient current at reference power factor to produce an indication at a scale mark near the middle of the measuring range. Record the value of the power (B_R) as shown by the reference instrument.

c) Decrease the input applied to the voltage circuits to the lower limit of their nominal range of use.

d) Change the power factor to the lagging value specified in Table 2 of IS 1248 (Part 3) and apply sufficient current to produce an indication at the same scale mark as in (b) and record the value of the power (B_{LI}) as shown by the reference instrument.

e) When required by Table 2 of IS 1248 (Part 3), change the power factor to the leading value specified in Table 2 of IS 1248 (Part 3) and apply sufficient current to produce an indication at the same scale mark as in (b). Record the value of the power (B_{LC}) as shown by the reference instrument.

f) Increase the input applied to the voltage circuits to the upper limit of their nominal range of use.

g) Change the power factor to the lagging value specified in Table 2 of IS 1248 (Part 3) and apply sufficient current to produce an indication at the same scale mark as in (b). Record the value of the power (B_{UI}) as shown by the reference instrument.

h) When required by Table 2 of IS 1248 (Part 3), change the power factor to the leading value specified in Table 2 of IS 1248 (Part 3) and apply sufficient current to produce an indication at the same scale mark as in (b). Record the value of the power (B_{UC}) as shown by the reference instrument.

5.15.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to the simultaneous influence of voltage and power factor shall be the greatest of the values computed as follows:

At the lower limit of voltage (lagging power factor),

$$\left(\frac{B_R - B_{LI}}{A_F}\right)\times 100$$

At the lower limit of voltage (leading power factor),

$$\left(\frac{B_R - B_{LC}}{A_F}\right)\times 100$$

At the upper limit of voltage (lagging power factor),

$$\left(\frac{B_R - B_{UI}}{A_F}\right)\times 100$$

At the lower limit of voltage (leading power factor),

$$\left(\frac{B_R - B_{UC}}{A_F}\right)\times 100$$

5.16 Variation Due to Interaction Between the Different Measuring Elements of Polyphase Instruments

If any of the tests of this sub-clause require a value of current exceeding the maximum permitted value for the instrument under test, a lower initial value of excitation shall be selected.

If, due to the construction of the instrument, a given current circuit is common to more than one measuring element (for example, two-and-a-half-element wattmeters), this test cannot be applied.

Instruments utilizing electronic devices obtaining their supply from a voltage measuring circuits shall not be subjected to their test.

5.16.1 *Procedure*

a) Connect the instrument with one of the voltage circuits open circuited. Apply sufficient excitation to the other voltage circuit(s) at rated voltage and at reference frequency to produce an indication at a scale mark near to the middle of the measuring range by adjusting the currents (keeping them about equal) in each phase. Record the value of the excitation (B_R),as shown by the reference instrument.

b) Vary through 360° the phase of the current in the current circuit whose corresponding voltage circuit is disconnected. Select that phase change which produces the greatest change in the indication. Adjust the currents (keeping them about equal) in each phase to produce an indication at the same scale mark as in (a). Record the value of the excitation (B_P) with the most unfavourable phase condition.

c) Repeat (a) and (b) while open-circuiting the other voltage circuits sequentially.

d) Repeat (a), (b) and (c) with rated current while sequentially open-circuiting one of the current circuits and varying the phase of the corresponding voltage circuit through 360°.

5.16.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to interaction between the measuring elements of polyphase instruments shall be greatest of the values computed as follows:

$$\left(\frac{B_R - B_P}{A_F}\right)\times 100$$

5.17 Variation Due to Auxiliary Supply Voltage

5.17.1 *Procedure*

a) Energize the instrument at its rated supply voltage and reference frequency or at a voltage and frequency within the reference range and apply sufficient excitation with tapping to bring the index to a scale mark near 80 percent of the upper limit of the measuring range. Record the value of the excitation (B_R) as shown by the reference instrument.

b) Decrease the supply voltage to the lower limit of the nominal range of use and record the value of the excitation (B_X) to produce an indication at the same scale mark as in (a).

c) Increase the supply voltage to the upper limit of the nominal range of use and record the value of the excitation (B_Y) to produce an indication at the same scale mark as in (a).

5.17.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to auxiliary supply voltage shall be the greater of the values computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right)\times 100 \quad \text{and} \quad \left(\frac{B_R - B_Y}{A_F}\right)\times 100$$

5.18 Variation Due to Auxiliary Supply Frequency

5.18.1 *Procedure*

a) Energize the instrument at its rated supply voltage and reference frequency or within the reference range for frequency and apply sufficient excitation to bring the index (with tapping) to a scale mark near 80 percent of the upper limit of the measuring range. Record the value of the excitation (B_R) as shown by the reference instrument.

b) Decrease the supply frequency to the lower limit of the nominal range of use and record the value of the excitation (B_X) to produce an indication at the same scale mark as in (a).

c) Increase the supply frequency to the upper limit to the nominal range of use and record the value of the excitation (B_Y) to produce an indication at the same scale mark as in (a).

5.18.2 *Computation*

The absolute value of the variation, expressed as a percentage, due to auxiliary supply frequency shall be the greater of the values computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right)\times 100 \quad \text{and} \quad \left(\frac{B_R - B_Y}{A_F}\right)\times 100$$

6 OTHER TESTS

6.1 Limiting Values of Temperature

6.1.1 *Procedure*

a) Subject the instrument to the high value of the limiting value of temperature ± 2° C while energized continuously at 80 percent of the upper limit of the measuring range for a 16 h period.

b) Subject the instrument to the low value of the limiting value of temperature ± 2°C while energized continuously at 80 percent of the upper limit of the measuring range for an 8 h period.

c) Repeat (a).

d) Repeat (b).

e) Repeat (a). Immediately after completion of the 16 h period and while at the high temperature, slowly increase and decrease the excitation so that the index reaches the upper limit of the measuring range and returns to zero.

f) Repeat (b). Immediately after completion of the 8 h period and while at the low temperature, slowly increase and decrease the excitation so that the index reaches the upper limit of the measuring range and returns to zero.

g) Return the instrument to the reference temperature, maintain it at that temperature for at least 2 h. Set zero and repeat the appropriate intrinsic error test.

6.1.2 *Computation*

The error shall be computed as indicated for the appropriate intrinsic error test given in **4**.

6.2 Overshoot

6.2.1 *Procedure for Mechanical Zero not on the Scale or Indeterminate*

a) Measure and record the scale (B_{SL}) in units of length.

b) Apply a constant value of excitation to given a deflection corresponding to the lower limit of the measuring range.

c) Suddenly increase (for example by switching) the excitation to a value that would give a steady deflection of approximately two-third of the scale length.

d) Measure and record the length of the overshoot (B_X) of the index (in units of length) on the first swing.

6.2.2 *Procedure for All Other Instruments*

a) Measure and record the scale length (B_{SL}) in units of length.

b) Suddenly apply a constant value of excitation that would give a steady deflection of approximately two-third of the scale length.

c) Measure and record the length of the overshoot (B_X) of the index (in unit of length) on the first swing.

NOTES

1 When the zero of the instrument is displaced within the scale, the scale length is taken as the longer of the scale lengths on either side of the zero.

2 When overshoot is influenced by the circuit impedance, the impedance of the driving source is to be as specified in the relevant parts.

3 In special cases, the external circuit impedance may be as agreed between the manufacturer and the user.

6.2.3 *Computation*

The overshoot as percentage shall be computed as follows:

$$\left(\frac{B_X}{B_{SL}}\right)\times 100$$

6.3 Response Time

6.3.1 *Procedure for Mechanical Zero not on the Scale or Indeterminate*

a) Measured and record the scale length (B_{SL}) in units of length.

b) Apply a constant value of excitation to produce a deflection corresponding to the lower limit of the measuring range.

c) Suddenly increase (for example by switching) the excitation to a value that will produce a steady deflection of approximately two-third of the scale length.

d) Measure and record the time in seconds required for the index to come to apparent rest while remaining within a band on either side of its final rest position of length equal to 1.5 percent of the scale length.

e) Repeat (b), (c) and (d) five times and take average.

6.3.2 *Procedure for All Other Instruments*

a) Measure and record the scale length (B_{SL}) in units of length.

b) Suddenly apply a constant value of excitation that will produce a steady deflection of approximately two-thirds of the scale length.

c) Measure and record the time in seconds required for the index to come to apparent rest while remaining within a band on either side of its final rest position of length equal to 1.5 percent of the scale length.

d) Repeat (b) and (c) five times and take the average.

NOTES

1 When response time is influence by the circuit impedance, the impedance of the driving source is to be as specified in the relevant parts.

2 When the zero of the instrument is displaced within the scale, the scale length is taken as the longer of the scale lengths on either side of the zero.

3 In special cases, the external circuit impedance may be as agreed between the manufacturer and the user.

6.3.3 *Computation*

There is no computation.

6.4 Overloads of Short Duration for Instruments

6.4.1 *Procedure*

a) When required by the relevant parts, measure and record the scale length (B_{SL}) in units of length. Set zero.

b) Apply overloads as specified in the relevant parts.

c) One hour after the completion of (b) record the deviation of the index from zero (B_O) in units of scale length.

d) Set zero and repeat the appropriate intrinsic error test given in **4**.

6.4.2 *Computation*

The deviation from zero, expressed as a percentage of the scale length, shall be computed as follows:

$$\left(\frac{B_O}{B_{SL}}\right)\times 100$$

The effects due to overloads of short duration shall be computed as indicated for the appropriate intrinsic error test given in **4**.

6.5 Overloads of Short Duration for Accessories

6.5.1 *Procedure*

a) Subject the accessory to overloads as specified in IS 1248 (Part 8).

b) After the accessory has cooled to the reference temperature, the appropriate intrinsic error test given in **4** shall be repeated.

6.5.2 *Computation*

The effects due to overloads of short duration shall be computed as indicated for the appropriate intrinsic error test given in **4**.

6.6 Continuous Overload for Instruments

6.6.1 *Procedure*

a) For ammeters and voltmeters, measure and record the scale length (B_{SL}) in units of length.

b) Set zero and apply overloads equal to the value specified in the relevant parts for a period of 2 h.

c) Reduce the excitation to zero with tapping. For ammeters and voltmeters, immediately measure and record the deviation of the index from zero in units of scale length (B_{TD}).

d) Approximately 2 h after the completion of (c), set zero and repeat the appropriate intrinsic error test given in **4**.

NOTES

1 On frequency meters, the potential circuit(s) will be subjected to a voltage overload.

2 On wattmeters, varmeters, phasemeters and power factor meters, the potential circuits and current circuits are individually overload with the other circuit(s) excited at rated voltage or current.

6.6.2 *Computation*

The effect of continuous overload, expressed as a percentage, shall be computed as indicated for the appropriate intrinsic error test given in **4**. For ammeters and voltmeters, the temporary effect of continuous overload, expressed as a percentage of scale length, shall be computed as follows:

$$\left(\frac{B_{TD}}{B_{SL}}\right)\times 100$$

6.7 Continuous Overload for Accessories

6.7.1 *Procedure*

a) Apply a continuous overload of 120 percent of the rated value for a period of 2 h.

b) Approximately 2 h after the completion of (a), the intrinsic error test for the accessory given in **4** shall be repeated.

6.7.2 *Computation*

The effects due to continuous overload shall be computed as indicated for the appropriate intrinsic error test given in **4**.

6.8 Current Circuit Continuity After High Current Overload

6.8.1 *Procedure*

a) For instruments with multiple measuring circuits, all circuits other than the one being tested shall be operated with rated excitation.

b) Apply the overload current as specified in the relevant parts to the current circuit being tested for the period specified in the relevant parts.

c) Disconnect the instrument and check the current circuit under test for continuity to determine if the current circuit has become an open circuit.

6.8.2 *Computation*

There is not computation.

6.9 Deviation from Zero

6.9.1 *Procedure*

a) Measure and record the scale length (B_{SL}) in units of length.

b) Energize the instrument for 30 s at the upper limit of the measuring range.

c) The excitation shall be quickly reduced to zero without causing any overshoot on the instrument under test. The instrument shall not be subjected to any vibration.

d) Without tapping, the deviation of the index from the zero scale mark in units of scale length (B_X) shall be measured and recorded 15 s after the excitation has been reduced to zero.

NOTE — For specially damped instruments, the time for reading the deviation from zero in (d) may be as agreed between the manufacturer and the user.

6.9.2 *Computation*

The deviation from zero, expressed as a percentage, shall be computed as follows:

$$\left(\frac{B_X}{B_{SL}}\right)\times 100$$

6.10 Effects of Vibration and Shock

6.10.1 *Procedure*

a) Set zero with tapping and apply sufficient slowly varying excitation under reference conditions to bring the index sequentially to each of at least five approximately equidistant scale marks includeing the lower and upper limits of the measruing range without tapping in both the upscale and downscale directions. Record the values of the excitation (B_R) as shown by the reference instruments.

b) Mount the instrument in its normal position of use and with the instrument de-energized and all measuring circuits short-circuited. Subject the instrument to sinusoidal vibration as specified in **7.5.1** of IS 1248 (Part 1).

c) With the instrument de-energized and all measuring circuits short-circuited, subject the instrument to shock as described in **7.5.2** of IS 1248 (Part 1).

d) Set zero with tapping and record the values of the excitation (B_X) to bring the index to the same marks as in (a) without tapping in both the upscale and downscale directions.

NOTE — The instrument should be so mounted that one of the three shock axes is parallel to the axis of rotation of the moving element.

6.10.2 *Computation*

The effect of vibration and shock, expressed as a percentage, shall be the greatest value computed for each selected scale mark for both upscale and downscale changes as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

6.11 Drop-Out Difference Frequency for Synchroscopes

6.11.1 *Procedure*

a) Connect the running circuit to a source having a voltage within the nominal range of use at refernce frequency (B_R).

b) Connect the incoming circuit to a separate but similar source of voltage whose frequency can be adjusted over a range of at least ±10 Hz around the frequency of the source connected to the running circuit.

c) Starting at the same frequency as the running circuit, reduce the frequency of the incoming circuit until the rotation of the moving element stops. Record the value of the frequency (B_L).

d) Increase the frequency of the incoming circuit until it is the same as the running circuit.

e) Continue increasing the frequency of the incoming circuit until the rotation of the moving element reverses and then stops. Record the value of the frequency (B_H).

NOTE — The 'incoming circuit' is that circuit which, in use, is normally connected to a source whose phase relative to another circuit, 'the running circuit', is to be adjusted so as to enable them to be synchronized.

6.11.2 *Computation*

The drop-out difference frequencies shall be computed as follows:

$$(B_L - B_R) \quad \text{and} \quad (B_R - B_H)$$

6.12 Pull-In Difference Frequency for Synchroscopes

6.12.1 *Procedure*

a) Connect the running circuit to a source having a voltage within the nominal range of use at reference frequency (B_R).

b) Connect the incoming circuit to a separate but similar source of voltage whose frequency can be adjusted over a range of at least ±10 Hz around the frequency of the source connected to the running circuit.

c) Starting at a frequency sufficiently lower than the reference frequency so as not to cause rotation of the moving element, increase the frequency of the incoming circuit until rotation of the moving element begins. Record the value of the frequency (B_L).

d) Continue to increase the frequency of the incoming circuit until the rotation of the moving element reverses and then stops.

e) Reduce the frequency of the incoming circuit until rotation of the moving element begins. Record the value of the frequency (B_H).

NOTE — The 'incoming circuit' is that circuit which, in use, is normally connected to a source whose phase relative to another circuit, 'the running circuit', is to be adjusted so as to enable them to be synchronized.

6.12.2 *Computation*

The pull-in difference frequencies shall be computed as follows:

$$(B_R - B_L) \quad \text{and} \quad (B_H - B_R)$$

6.13 Open Circuit for Synchroscopes

6.13.1 *Procedure*

a) Connect rated voltage at rated frequency to the running circuit with the incoming circuit open. Record the indication.

b) Connect rated voltage at rated frequency to the incoming circuit with the running circuit open. Record the indication.

c) De-energized all measuring circuits. Record the indication.

NOTE — The 'incoming circuit' is that circuit which, in use, is normally connected to a source whose phase relative to another circuit, 'the running circuit', is to be adjusted so as to enable them to be synchronized.

6.13.2 *Computation*

No computation is required.

6.14 Self-Heating

6.14.1 *Instruments*

6.14.1.1 *Procedure*

a) Condition the instrument and its non-interchangeable accessories under reference conditions, without excitation, for at least 4 h.

b) Apply a constant value of excitation with tapping that will bring the index to a scale mark as specified in **6.3.1** of IS 1248 (Part 1). Record the value of the excitation (B_R) after at least 1 min but less than 3 min of excitation.

c) After at least 30 min but less than 35 min of excitation, readjust the excitation to bring the index to the same scale mark as in b) with tapping. Record the value of the excitation (B_X).

6.14.1.2 *Computation*

The variation, expressed as a percentage, due to self-heating shall be computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

6.14.2 *Accessories*

6.14.2.1 *Procedure*

a) Condition the accessory under reference conditions, without energizing, for at least 4 h.

b) Energize the accessories in accordance with the requirements of **6.3.1** of IS 1248 (Part 1).

c) Using an indicating instrument with negligible self-heating error, record the value (B_S) of the accessory after at least 1 min but less than 3 min of excitation.

d) Record the value (B_X) of the accessory after at least 30 min but less than 35 min of excitation.

6.14.2.2 *Computation*

The variation, expressed as a percentage, due to self-heating shall be computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

6.15 Ohmmeter Maximum Current

6.15.1 *Procedure*

a) Connect a low value four-terminal resistor (R_{T1}) across the measuring terminals of the ohmmeter.

b) Measure the voltage drop across the four-terminal resistor (V_{R1}) using a high impedance voltmeter. Compute the current (I_{R1}) through the resistor.

c) Double the value of the four-terminal resistor (R_{T2}) and measure the voltage drop (V_{R2}) across the resistor. Compute the current (I_{R2}) through the resistor.

d) If I_{R2} is less then 95 percent of I_{R1}, reduce the value of the four-terminal resistor used in (a) and repeat (a) to (d).

6.15.2 *Computation*

The ohmmeter maximum current shall be computed as follows:

$$\left(\frac{V_{R1}}{R_{T1}}\right)$$

6.16 Voltage Circuit(s) only Energized for Wattmeters and Varmeters

6.16.1 *Procedure*

a) Measure and record the value of the indication (B_R), with the voltage circuit(s) energized at rated voltage and the current circuit(s) open circuited, but, where appropriate, connected to the voltage circuit(s) as in normal operation. If the index deflects below the first scale mark, readjust the mechanical zero to produce an indication at the first scale mark.

b) De-energize the voltage circuit(s) and record the value of the indication (B_X).

6.16.2 *Computation*

The effect, expressed as a percentage, of energization of the voltage circuits(s) only shall be computed as follows:

$$\left(\frac{B_R - B_X}{A_F}\right) \times 100$$

6.17 Tracking Error

NOTE — A requirement for a test for tracking error is not given in IS 1248 (Part 1). However, test for tracking error may be carried out by agreement between the manufacturer and the user. If so, the method should be as given in this sub-clause. It should be noted that this method is not in conformity with the definition of tracking error, which is given in **3.7.3** of IS 1248 (Part 1) but is based on the following modified definitions:

Tracking error: The error, which affects the ability of an instrument to indicate correctly at a scale mark being checked when energized by the corresponding proportional value of the actual end-scale excitation.

6.17.1 *Procedure*

a) Set the mechanical zero with tapping except that for instruments, on which the zero is not on the scale, no zero adjustment is to be made.

b) Under reference conditions and with tapping, measure and record the value of the excitation (B_R), as shown by the reference instrument, to bring the index to the scale mark at the upper limit of the measuring range (A_R). For instruments having the zero scale mark within the scale, the higher or, if both end scale values are equal, the right hand scale mark shall be used.

c) Select a minimum of four other indicated scale marks within the measuring range (A_{AR}), (A_{BR}), (A_{CR}) and (A_{DR}) so that the measuring range is divided into approximately equal intervals.

d) Determine the value of excitation (B_{AX}), (B_{BX}), (B_{CX}) and (B_{DX}), as shown by the reference instrument, to produce indications, with tapping, at the scale marks selected in (c).

6.17.2 *Computation*

The tracking error in percent shall be computed for each selected indicated value as follows:

$$\left(\frac{A_{AR}}{A_R}-\frac{B_{AX}}{B_R}\right)\times\frac{A_R}{A_F}\times 100,\quad \left(\frac{A_{BR}}{A_R}-\frac{B_{BX}}{B_R}\right)\times\frac{A_R}{A_F}\times 100,$$

$$\left(\frac{A_{CR}}{A_R}-\frac{B_{CX}}{B_R}\right)\times\frac{A_R}{A_F}\times 100 \text{ and } \left(\frac{A_{DR}}{A_R}-\frac{B_{DX}}{B_R}\right)\times\frac{A_R}{A_F}\times 100$$

6.18 Range of Mechanical Zero Adjustment

6.18.1 *Procedure*

a) Operate the zero adjuster to move the index upscale and record the value of the greatest deflection of the index (D_U).

b) Repeat (a) to adjust the index downscale and record the value of the greatest deflection of the index (D_D). If the end stop inhibits the motion of the index while the zero adjuster is being operated or if the instrument has its zero off scale, (a) and (b) shall be performed with the instrument energized with the rated value for the major scale mark nearest to the middle of the measuring range.

c) Set the index to the zero or mid-scale mark (as appropriate).

d) Check that it is possible to reset the index sequentially to an indication, which corresponds to one-fifth of the class index above and below the reference mark used in (c).

6.18.2 *Computation*

The range of zero adjustment shall be computed as follows:

$$(D_U - D_D)$$

The ratio of the adjustment range shall be computed as follows:

$$\text{If } D_U > D_D,\ \text{ratio} = \left(\frac{D_U}{D_D}\right)$$

and

$$\text{If } D_U < D_D,\ \text{ratio} = \left(\frac{D_U}{D_D}\right)$$

6.19 Permanence of Marking

6.19.1 *Procedure*

a) Rub a portion of the marking lightly for 15 s with a clean cloth soaked with petroleum spirit.

b) Repeat (a) substituting water for the petroleum spirit.

c) Examine the marking to determine its legibility.

6.19.2 *Computation*

No computation is necessary.

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